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The Effect of a Focused Education Session on Continuous Renal Replacement Therapy (CRRT) Troubleshooting to Increase Knowledge and Self-Confidence in ICU Nurses.

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DNP Final Project Report

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Dedication

This DNP project is dedicated to my Dad. Growing up, you emphasized education and it seems that it has finally paid off. There will never be enough words to show my love, gratitude, and appreciation for you.

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I would like to acknowledge my advisor, Dr. Melanie Hardin-Pierce, for her constant support throughout the program. You encouraged me and gave me confidence, even when I doubted myself. For that and so many other things, I am grateful. To Dr. Karen Butler, thank you for your continued support and feedback. Without it, this paper would not have been possible. To Tracy Rexford, working with you has always been a joy. As coworkers in South, then nurse and clinical educator, and finally student and clinical advisor; thank you for everything through the years.

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Abstract

PURPOSE: The purpose of this study was to determine if education focusing on CRRT troubleshooting was effective at improving ICU nurses' knowledge and self-confidence levels. It was hopeful that, following the educational intervention, ICU nurses would have an increase in knowledge and report higher self-confidence levels regarding troubleshooting CRRT.

METHODS: This study involved the use of a pre-post-test and questionnaire to evaluate the efficacy of an educational intervention on ICU nurses' knowledge and self-confidence levels at Saint Joseph Hospital. The pre-post-test was used to evaluate knowledge levels, while the pre-post questionnaire was used to evaluate self-reported confidence levels.

RESULTS: From October 1, 2018 to December 31, 2018, 30 ICU nurses participated in the educational intervention. The findings revealed a statistically significant increase in overall knowledge (p = <0.001), with a mean pre-test score of 6.87 ± 1.548 and a mean post-test score of 9.10 ± 0.885. Following the educational intervention, participants reported an increase in self-confidence levels regarding overall continuous renal replacement therapy (p = 0.001), troubleshooting skills (p = <0.001), and re-infusing (p = <0.001).

CONCLUSION: CRRT troubleshooting education was shown to be significant in improving knowledge and self-confidence levels of ICU nurses. A routine educational intervention to improve education and self-confidence in the management and troubleshooting of CRRT was effective at increasing ICU nurse knowledge and self-confidence levels. Improved knowledge levels and self-confidence in managing CRRT may lead to decreased down time and improved patient outcomes in the future.

The Effect of a Focused Education Session on Continuous Renal Replacement Therapy Troubleshooting to Increase Knowledge and Self-Confidence in ICU Nurses

Introduction

For patients who are dealing with acute kidney injury in the midst of sepsis and multiple organ dysfunction syndrome, continuous renal replacement therapy (CRRT) is often needed to bridge patients during their chronic illness until the acute kidney injury (AKI) has resolved or until they are stable for hemodialysis. At baseline, the mortality rate for patients with AKI in the setting of multi-system organ involvement is already somewhere around 40% (Zarbock et al., 2016). Any delay in treatment, when it is indicated, has been shown to increase morality rates even further: to almost 60% (2016). Due to the severity of their conditions, patients with AKI in the setting of multi-system organ involvement are almost always in the intensive care unit (ICU), where they are cared for by nurses who must be knowledgeable and feel confident in managing CRRT. Unfortunately, many ICU nurses are insufficiently trained or lack the appropriate experience to effectively manage CRRT. A recent study found that over half of reported incidents associated with CRRT involved nursing educational deficits, such as the inability to troubleshoot alarms associated with the machine (Mottes et. al, 2013).

An informal polling of ICU staff nurses at a 433-bed for profit community hospital in Kentucky found that many nurses, experienced and inexperienced alike, were unsure and often felt overwhelmed with the responsibilities involved with managing CRRT. They were not confident in their ability to manage or troubleshoot CRRT. They typically only receive one introduction class about managing CRRT, which occurs when they are first hired into the ICU. However, it is often many months or even a year between the time a nurse has this class to when he or she is first required to care for a patient with this therapy. This extended time-lapse can make it very difficult to maintain skill and knowledge levels. A seminar taught by the CRRT

company representative will occasionally be offered, but this is quite rare. Based on the ICU nurses' responses, the introduction class and occasional seminar is simply not enough to maintain competency.

Background and Significance

The National Kidney Foundation defines acute renal failure as failure of the kidneys to filter waste and maintain normal fluid balance, usually occurring suddenly over the course of several hours to days (2018). Acute renal failure can be found in up to 18% of hospitalized patients and is the cause of around 1.7 million deaths annually (Tsujimoto, 2016). Studies show around 50% of patients admitted into the ICU experience acute renal failure, and up to 6% of those patients require a form of renal replacement therapy at some point (2016). The two main forms of renal replacement therapy offered in the critical care setting are the more traditional hemodialysis and CRRT. In hemodialysis, three or four liters of fluid may be removed from a patient in one sitting, typically three to four hours long. With CRRT, only one to two liters may be removed over a span of 24 hours; a much slower and gradual process.

For patients who are too unstable to tolerate traditional hemodialysis, typically those with hypotension and who require at least one vasopressor, CRRT may be their best option. The goal of CRRT is to provide continuous ultrafiltration while also cleansing the blood of metabolic byproducts, balancing electrolytes, and maintaining the body's acid-base system until the patient's kidney function improves and the patient can either tolerate hemodialysis or no longer requires dialysis of any kind (Rewa et. al, 2015).

Despite having the word continuous in the name, there are some expected periods of down time with CRRT. Down time is considered to be any time therapy is not running, such as patient procedures or routine filter changes. During hemodialysis and CRRT, the filter acts as an artificial kidney: removing unwanted toxins and solutes from the blood (Gambro, 2015). For

patients with severe sepsis or rhabdomyolysis, there are elevated circulating blood levels of myoglobin, cytokines, interleukins, and/or other waste products (Fresenius Medical Care, 2019). These waste products will clog a filter, eventually to the point where it is no longer effective. As a result, filters are typically changed at a routine interval, usually around 72 hours. However, it is common for filter lifespans to be lower than average during the first day or two of CRRT, as a result of large amounts of waste products circulating in the blood due to kidney failure (Brain, Winson, Roodenburg, & McNeil, 2017).

Filters can not only clog but can clot as well. Anytime blood is present, clotting will eventually occur. Anticoagulants can be prescribed and infused directly into the dialysis circuit, which can help prolong the filter's lifespan. But even with anticoagulant, filters can and do clot off, often before the ideal 72-hour timespan has passed. If there are continued signs of filter clotting, it is important to return, or re-infuse, the blood back to the patient. Once the filter has fully clotted off, the CRRT machine will not allow the nurse to return the blood back to the patient, resulting in a sudden blood loss, which can be as much as 300mL, making these patients even more unstable and hypotensive. It can also increase the need for blood transfusions, which are associated with risk and contributes to further fluid overload (Al-Dorzi et al., 2019).

Being able to predict when a filter may clot or clog off is an important, and often overlooked, aspect of running CRRT. There are many signs of impending filter failure: pressure drop, rising transmembrane pressure (TMP), filter pressure alarms, and the actual alarm of "filter is clotting" (Gambro, 2015). For each of these alarms, there are actions the nurse must take to fix the problem that triggered the alarm. These actions will hopefully prolong the filter life for a longer period of time. Davies et al. found that the most common reason for treatment delays was from filter clotting, almost 50% of cases (2017). The mean down time in these particular cases was three and a half hours (2017). As mentioned previously, any prolonged down time or delays

in treatment can increase a patient's mortality. While nothing can be done to stop a filter from eventually clogging or clotting, an experienced and knowledgeable nurse can take the appropriate steps to prolong the filter life and limit/avoid unnecessary down time.

Having experienced and knowledgeable nurses is especially important when the bedside ICU nurses depend on a specialized dialysis nurse to initiate CRRT and perform all filter changes. As there are often no dialysis nurses in house on night shift, the on-call nurse must be notified to come in if there are filter problems throughout night. Unfortunately, this can extend the period of down time where the patient is not benefiting from CRRT, placing them at increased risk for complications. It is vital that ICU nurses are competent and confident in their abilities to manage CRRT and any problems that may arise during treatment. Currently, a gap exists in the knowledge/competency level of the nurses to safely manage patients requiring CRRT. There is also a gap in the nurses' level of self-confidence in their ability to manage CRRT in critically ill patients.

Currently, there are no specific measures dedicated to increasing nursing knowledge and self-confidence in CRRT troubleshooting knowledge at this hospital setting. The current CRRT training for new critical care nurses is through an in-person class offered at some point during the three-month critical care orientation period and typically lasts about seven hours. Unfortunately, it may be several months between the training class and the opportunity to actually care for a patient with CRRT. This extended time between education and application leads to the erosion of competency and self-confidence of the nurses.

Literature Review

In an effort to design an evidence-based method of increasing nursing knowledge and self-confidence regarding CRRT management and troubleshooting, a review of the literature was performed. Four subtopics were focused on extensively in this literature review: the effect of

CRRT education on nursing confidence, effect of CRRT education on filter life, effect of CRRT education on down time, and effect of CRRT education on alarm management. Searches of PubMed, Medline, CINAHL, and BioMed Central databases were completed using three different keyword searches: CRRT AND education AND nursing, CRRT AND nursing AND filter, and CRRT AND nursing. The search for research articles was limited to those in the English language, published in the last ten years, and only involving CRRT. Studies involving hemodialysis and peritoneal dialysis were excluded. Randomized control trials, systematic reviews, qualitative studies, and meta analyses were included in the review. By using these keyword searches and limitations, a total of 85 articles were retrieved from the four databases. After assessing titles and abstracts of the search results, nine studies met inclusion criteria and were selected to serve as evidence for this project.

Self-Confidence

Four studies in this review used nursing self-confidence as a measurement for CRRT education. In all four studies, nurses expressed greater self-confidence in managing CRRT after focused education. In the studies performed by Przybyl, Androwich, & Evans (2013) and Graham & Lischer (2011), hands-on simulation was used in addition to traditional didactic method. Przybyl et al. had nurses take a pre-/post-questionnaire regarding their perceived abilities (2013). Nurses reported a 10% increase in overall CRRT skill level and a 15% increase in CRRT troubleshooting abilities following education (2013). Graham & Lischer found that nurses reported a general overall increase in confidence when caring for CRRT after both didactic and simulation sessions (2011).

Windt (2016) developed an online education model that included videos and learning exercises. Of the nurses who participated in this model, 72% reported an increase in their level of confidence concerning CRRT (2016). Huang & Hsu (2011) developed a self-learning manual

to help increase the knowledge of the staff and to measure efficacy with the help of pre-/post-tests and a self-assessment survey. The mean response score from the self-assessment survey before the manual was 79.75. (2011). Following introduction of the manual, the mean response scores rose to 91.06, which represented a mean increase of 10.35 (2011).

Filter Life

Four studies in this review looked at filter changes and filter life to help evaluate CRRT education. All four studies found a measurable decline in unexpected filter changes and an increase in filter life following focused CRRT education. Przybyl (2013) found there was a 35.8% decrease of unexpected filter changes, while Mottes et al. (2013) showed a decrease from 56.2% to 47.9%. In their study, Mottes et al. (2013) also discovered the median filter life increased from 42.5 hours to 59.4 hours following simulation-based education. Page et al. (2014) found that the median filter life increased from 33 hours to 55 hours after focused education. Oh et al. (2014) developed and implemented a specialized team involving physicians and nurses who were specially trained and educated in CRRT. Following this team implementation, filter life rose from 25.7 hours to 31.1 hours (Oh et al., 2014).

Down Time

Two studies featured in this review examined down time and how it was affected by CRRT education. Oh et al. (2014) measured both down time in hours per day and lost time with filter changes per day, in minutes. Following the implementation of their specialized team, down time dropped from 4.8 hours per day to 3.3 hours per day, while lost time with filter changes dropped from 42 minutes down to 23 minutes per exchange (2014). Kee et al. (2015) also looked at the effects of a specialized team on CRRT and patient care. In their study, average down time in hours per day was 5.1 before the implementation of this team (2015). After this team approached was used, down time decreased to 3.2 hours per day (2015).

Alarm Management

Finally, one study from this review examined how CRRT education affected alarm management and resolution. Choi & Yi (2014) created a schematized alarm-managing manual to help the bedside nurses managing CRRT. Two ICUs were used in this study to help measure its efficacy: the ICU who received the manual (experimental group) and the ICU who did not receive the manual (control group) (2014). Following implementation of the manual, total alarm resolution rate in the control group was 37.3%, while the experimental group showed a resolution rate of 45.8% (2014).

Unfortunately, there are several limitations and gaps in evidence with this particular topic. First, there are several studies that use different teaching and training methods. However, there has yet to be one method that has been shown to be most effective at educating nurses regarding CRRT. Second, most of the relevant studies only involved the initial education or initial simulation course. There is little information available that recommends a frequency for CRRT education and competency upkeep for experienced nurses. Finally, there were no studies that looked at the effect of a simple educational intervention that is specifically geared towards troubleshooting, without the use of hands-on simulation, specialized teams, or an extensive manual, and how it would affect nursing knowledge and self-confidence.

Conceptual Framework

The Johns Hopkins Nursing Evidence-Based Practice Model was the framework that helped guide this research study. This model uses a three-step process to quickly identify a problem and appropriately implement the evidence-based findings in order to improve patient care and outcomes (Johns Hopkins Health, 2017). The first step, practice question, involves identifying or asking what the problem is (2017). During the second step, the evidence gathered during research is synthesized and recommendations are developed based on these findings

(2017). Finally, the synthesized findings from step two are translated into action. This involves determining feasibility of recommendations, creating and implementing an action plan, evaluating outcomes, and identifying next steps (2017).

Theoretical Framework

The theoretical framework that guided this research study was the Patricia Benner Novice to Expert Theory (Health Research Funding, 2019). In this theory, Patricia Benner proposed that there are five stages of nursing clinical competence; novice, beginner, competence, proficiency, and expert (2019). According to Benner, every nurse begins as a novice (2019). As a nurse receives more education and gains more experience, he or she slowly rises through the five stages, until they finally become an expert (2019).

This theoretical framework is especially useful in measuring the knowledge/competency levels of ICU nurses in regard to CRRT troubleshooting. As Benner theorized, every nurse will start out as a novice when he or she first begins to manage CRRT. While experience is important in moving through the five stages of competence, education cannot be overlooked. Consistent education will be an important factor in moving nurses through the five stages: from novice to expert.

In this research study, the primary researcher identified a problem by observing her coworkers manage CRRT patients at Saint Joseph hospital for the past eight and a half years and conducting an informal polling of her coworker regarding their thoughts and concerns about CRRT management. The primary researcher then studied the most recent evidence available regarding CRRT education and its relationship to nursing knowledge and self-confidence. Based on these findings, the primary researcher developed and implemented an action plan.

Purpose

This purpose of this project was to improve nursing knowledge and self-confidence regarding CRRT management and troubleshooting at Saint Joseph Hospital. Based on a review of the peer reviewed research, an evidence-based educational intervention for ICU nurses that was specifically geared towards increasing nursing knowledge (troubleshooting CRRT and managing any other problems that may occur) and self-confidence was developed and implemented. Nursing knowledge and self-confidence at baseline and following an education intervention were evaluated. The specific aims of this study were:

A. To assess the effectiveness of focused CRRT troubleshooting education on knowledge level in ICU nurses
B. To assess the effectiveness of focused CRRT troubleshooting education on self-confidence in ICU nurses.

Methods

This study used a pretest-posttest design to evaluate the effectiveness of a CRRT educational intervention on increasing nursing knowledge and self-confidence levels. The educational intervention consisted of a PowerPoint with instruction from the primary researcher that included information about the most common troubleshooting topics that occur during routine CRRT therapy: alarm types (caution, advisory, warning), how to manage each alarm (specifically high filter, access, and return pressure alarms), transmembrane pressure (TMP), pressure drop, re-infusing, and when to notify the dialysis nurse about an impending need for filter change.

Setting

Saint Joseph Hospital was the chosen site for this study. Located in Lexington, KY, Saint Joseph Hospital is a 433-bed tertiary care center that primarily serves adults 18 years and older

from central and eastern Kentucky. Within this hospital, there are four critical care units; South ICU, Neuro ICU, CCU, and CTVU. All four of the units are capable of managing patients who require CRRT. CTVU nurses regularly receive education from within the unit regarding various patient care therapies, including CRRT. CTVU is also the largest unit in the hospital and frequently has patients who require CRRT; much more so than the other three units. Due to these facts, it was decided that CTVU nurses would not benefit from a CRRT educational intervention and only nurses from South ICU, Neuro ICU, and CCU were invited to participate. No comparison was done between this research study and the education received by CTVU nurses.

Sample

The only exclusion criteria to this study were non-critical care nurses and critical care nurses who had never managed CRRT before. Non-critical care nurses were excluded because CRRT is only performed in the critical care setting. Nurses who had never managed CRRT before were excluded because an educational intervention specifically regarding troubleshooting would be ineffective, as these nurses have no CRRT foundation to begin with. Inclusion criteria included critical care nurses who had managed CRRT before. A total of 30 nurses from South ICU, Neuro ICU, and CCU participated in this voluntary study, including both dayshift and nightshift, from October 2018 – December 2018. Each participant was given a cover letter detailing the purpose of the study, with an emphasis on completely voluntary participation. See Appendix 1 for the cover letter. By keeping results of the pre- and post-tests and questionnaires anonymous, the cover letter also made clear that their status as an employee at Saint Joseph Hospital would not be affected by their decision to or to not participate. All phases of this research, including the test, questionnaire, and educational intervention, were performed at the nursing unit where each participant worked.

Data Collection

Approvals from the chief nursing officer at Saint Joseph Hospital and the University of Kentucky Institutional Review Board (IRB) were obtained prior to the start of this research study. A ten-question multiple choice test was used to evaluate both pre- and post-intervention knowledge levels, with zero being the lowest score possible and ten being the highest score possible. Questions for the test were developed by the primary investigator and taken from the user manual that is included with the Baxter CRRT machines used by Saint Joseph Hospital (Gambro, 2015). See Appendix 3 for the complete test. To evaluate self-confidence levels pre- and post-intervention, a 3-item questionnaire using a 5-point Likert scale was used. A response of one indicated the lowest level of self-confidence, while a score of five indicated the highest level of self-confidence; a response of three was indicative of neutrality. See Appendix 4 for the complete questionnaire. The questions were the same on both the pre- and post-test and pre- and post-questionnaire. Reliability was not measure, but face validity was measured by educational experts and colleagues.

Immediately prior to the educational intervention, participants filled out a demographic survey, followed by the pre-test to assess knowledge and a pre-questionnaire to assess self-confidence. See Appendix 2 for complete survey. Immediately after the intervention, participants filled out the post-test and post-questionnaire. Responses to both the test and questionnaire were kept anonymous and were de-identified so that the data was not able to be linked to any one participant. In order to keep demographic information confidential, participants were not asked to specify which critical care unit they worked in. All data gathered during this phase of the study was transferred into an electronic spreadsheet.

Data Analysis

Demographic statistics were summarized through the use of frequency distributions and percentages. All variables in the demographic survey were categorical. A paired samples t-test was used to analyze the difference between the pre- and post-test and questionnaires, and to obtain the means, standard deviations (SD), and *p*-values. All analysis was done through SPSS version 24, with an alpha level of 0.05 used for statistical significance.

Results

Sample Characteristics

A total of 30 nurses participated in this study. The majority of participants were female (90%) and Caucasian (96.7%). Participants' age ranged from 20-64, with the most common range being 25-34 (33.3%). A little over half (53.3%) of participants had a bachelor's degree, while 46.7% had an associate degree. There were no nurses featured in this study who had a diploma in nursing. Finally, years of nursing experience ranged from one year to greater than 31 years. The most common years of experience range was 6-10 years (30%), followed closely by 1-5 years (26.7%) and 11-15 years (26.7%). See Table 1 for a complete breakdown of demographics.

Nursing Knowledge

Nursing knowledge regarding CRRT troubleshooting was improved following the educational intervention; see Table 2. Prior to the educational intervention, the mean pre-test score was 6.87 (SD = 1.548). Following the intervention, the mean post-test score increased to 9.10 (SD = 0.885). This difference was statistically significant, with $p = <0.001$. The mean average score from pre-intervention to post-intervention increased overall by 2.233 points (SD = 1.569).

While only one question (#4) on the pre-test averaged 90% or greater, there were a total of eight questions on the post-test that had an average score of 90% of greater. The two questions that were the most commonly missed on both the pre- and post-test were:

6. What does a rise in TMP pressure indicate?
7. What does pressure drop indicate?

The average pre-test score for question #6 was 50%, while the average score for #7 was a meager 26.7%. Even though the average score for both of these questions did rise significantly following the educational intervention, the scores were still well below that of the other questions. These findings are important and should be noted for future education opportunities. See Figure 1 for a comparison of correct answers on the pre-test versus post-test.

Self-Confidence Level

Along with knowledge level, self-reported confidence levels also increased following the educational intervention; see Table 3. The confidence level scores were analyzed in two ways: broken down individually by question, and then averaged together. The three questions on the questionnaire were:

1. I feel comfortable running CRRT.
2. I feel comfortable in my CRRT troubleshooting skills.
3. I feel comfortable re-infusing CRRT.

For question 1, the mean pre-intervention score was 3.60 (SD = 0.814). Following the intervention, the mean score rose to 4.00 (SD = 0.587); $p = 0.001$. The mean pre-score for question 2 was 3.10 (SD = 0.147), while the mean post-intervention score was 3.86 (SD = 0.108); $p = <0.001$. Finally, question 3 saw the biggest average increase of overall score. The

mean pre-score for question 3 was 3.13 (SD = 0.202). After the intervention, the mean score increased to 4.00 (SD = 0.643), with $p = <0.001$.

When answers from all three questions were averaged together, the mean pre-intervention score was 3.277 (SD = 0.803) and the mean post-intervention score was 3.945 (SD = 0.496). With a $p = <0.001$, this increase in confidence was statistically significant. Lastly, the mean overall confidence score increased by 0.668 (SD = 0.487) points, from pre-intervention to post-intervention.

Discussion

The purpose of this study was to determine the efficacy of an educational intervention regarding CRRT troubleshooting on knowledge and self-confidence levels in ICU nurses. Based on the findings, it was able to be determined that even a short, informal educational intervention had significant positive effects for nurses. However, the intervention only occurred once, and it is likely that the increase of knowledge and confidence will not be permanent. Windt reported that the majority of ICU nurses believe biannual education would be the most effective frequency to maintain competency levels (2016). Determining the appropriate frequency for CRRT continuing education should be a high priority moving forward.

According to Benner's Novice to Expert Theory, the majority of nurses featured in this study before it began would most likely have been considered competent in their CRRT knowledge; they had organizational skills, could recognize patterns, and could implement care with consistent accuracy (Health Research Funding, 2019). Nurses at this level are starting to focus on enhancing speed and flexibility because they are gaining the ability to recognize how they should react in most situations (2019). Based on findings from this research study, education was the main factor in moving the CRRT knowledge level of the participating nurses into the proficient/expert levels (2019).

When dealing with a patient population that is typically highly unstable and always critically ill, it is important that nurses have enough knowledge and confidence to take charge and not hesitate when problems arise. A slow reaction by nurses to CRRT alarms has been associated with early filter clotting (Joannidis & van Straaten, 2007). Early filter clotting has been linked to greater mortality, longer days on the ventilator, and a greater length of stay in both the ICU and hospital (Al-Dorzi et al., 2019). Based on findings from this and other studies, the importance of continuing education as a means to improve patient care cannot be overstated: not only with CRRT, but with other complex therapies as well.

But for hospitals like St. Joseph Hospital, who are co-dependent on dialysis nurses and who may go many months between patients with CRRT, what is the best method for continuing education concerning CRRT? While there have been many studies concerning different modes of CRRT education (simulation, online education, specialized teams, etc.), no one study has developed and identified a surefire method. In order to identify the best strategy for St. Joseph Hospital, ICU nurses and the education department need to disseminate the evidence and close the practice gap. Another study will be required to examine which educational method and frequency has the most efficacy for nurses at this particular hospital.

Implications for Practice

As mentioned above, there were two questions on both the pre- and post-test that scored significantly lower than other questions. Question #6 asked about TMP and question #7 asked about filter drop. An increase in TMP indicates the filter is beginning to clog, while pressure drop is indicative of filter clotting (Gambro, 2015). While there are temporary fixes for increased TMP, the real takeaway from this alarm is that there is a filter problem brewing and the on-call dialysis nurse should be notified. There is no alarm or notification for filter drop; it is just one of the many scales the nurse looks at each hour (2015). An understanding of TMP and

pressure drop indicates the nurse has a thorough understanding of the physiology behind CRRT. Due to the high number of incorrect answers for both of these questions, there is an obvious need for further education regarding filters.

Based on findings from the self-confidence questionnaire, it appears as though many nurses were very unsure regarding re-infusing. In the preliminary stages of this study, one of the biggest concerns for the primary investigator was the amount of ICU nurses who were completely unaware of how to re-infuse blood back to the patient. A re-infusion of blood occurs any time a filter or circuit needs to be changed. But when a filter begins to clot unexpectantly, time is of the essence. Any delay could potentially allow the filter to clot completely, causing the patient to lose all of the blood that was circulating through the machine. Despite not being a common occurrence, it is incredibly important for nurses to know how to re-infuse and to be confident about it. Even a brief period of hesitation may result in these patients becoming even more critically ill.

Limitations

There were several limitations identified in this study design. The main limitations were the small sample size (n=30) and only occurring at a single site. A larger sample could have been gathered if CTVU was able to be included in the study. Another limitation was the inability to compare test results with demographics, such as age, education level, and years of experience. Since responses to the tests and questionnaires were anonymous and unable to be traced to any one demographic survey, this was unfortunately not an option. In regard to demographics, there was a definite lack of gender and ethnic diversity among participants. Due to the population of nurses in the state of Kentucky, this was somewhat unavoidable. Lastly, the location of the study itself was a limitation. Due to the fact that the pre-test and questionnaire, educational

intervention, and post-test and questionnaire occurred at nursing stations, it is possible that participants might have been rushed or distracted: thus, unable to fully concentrate.

Recommendations for Future Studies

A future study regarding CRRT education should be able to link education level, age, and years of nursing experience to the test results. While it may seem obvious that higher education levels and more years of experience would be linked to higher test scores, this is not always the case. According to McHugh and Lake, the passage of time and experience gained does not always translate to expertise in clinical nursing (2010). Another study could find that it is the younger, less-experienced nurses who are, in fact, more knowledgeable about CRRT as a whole.

Future research should also investigate different types of educational methods. Hands-on simulation was unable to occur in this study due to the lack of a "practice" mode with the Baxter CRRT machines at St. Joseph Hospital. However, an update in the Baxter software or an overall update with the machines may make this a possibility in the future. But despite not having the ability to have hands-on simulation, other types of methods could still be studied; such as more advanced online education, specialized teams, or a self-learning manual. It has been shown that prolonged filter life can lead to reduced nurse workload, costs, and infection rates (Wang et al., 2014). Further research could look at various education methods and their effects on filter life, down time, nursing workload, costs, and infection rates.

Finally, a larger, multi-institutional study would allow for a greater generalizability of results. However, this may be difficult in the city of Lexington. As mentioned previously, St. Joseph Hospital is the only hospital in the city that uses specialized dialysis nurses to set up CRRT and perform filter changes. Further studies may need to occur outside of the city in order to gather larger amounts of data.

Conclusion

With an average mortality rate of around 40%, and even higher in some cases, patients requiring CRRT need critical care nurses who are knowledgeable and confident about this particular therapy. A lack of knowledge, in regard to troubleshooting, has been shown to cause increased down time, decreased filter life, and have a negative impact on patient outcomes. The purpose of this study was to evaluate the effect of CRRT troubleshooting education on knowledge and self-confidence levels in ICU nurses at St. Joseph Hospital, a hospital that is unique in their CRRT infrastructure. The results showed there is a positive correlation between CRRT education and nursing knowledge and self-confidence levels. Despite the findings in this study, a larger, more in-depth study is needed to truly know which education method and what frequency is best for nurses at St. Joseph Hospital. This research study helped to identify a disparity between education and practice. In the future, it will hopefully be used as the launching point for an evidence-based practice transformation.

Table 1. *Demographics*

Variable	Frequency (%)
Gender	
Male	3 (10%)
Female	27 (90%)
Ethnic Origin	
American Indian/Alaskan Native	0 (0%)
Asian	0 (0%)
Black/African American	0 (0%)
Hispanic/Latino	1 (3.3%)
Native Hawaiian/Pacific Islander	0 (0%)
White/Caucasian	29 (96.7%)
Other	0 (0%)
Age	
20-24	4 (13.3%)
25-34	10 (33.3%)
35-44	8 (26.7%)
45-54	2 (6.7%)
55-64	6 (20%)
65 or above	0 (0%)
Degree Level	
Diploma	0 (0%)
Associate	14 (46.7%)
Bachelor's	16 (53.3%)
Years of Nursing Experience	
Less than one year	0 (0%)
1-5 years	8 (26.7%)
6-10 years	9 (30%)
11-15 years	8 (26.7%)
16-20 years	1 (3.3%)
21-25 years	0 (0%)
26-30 years	2 (6.7%)
31 years or greater	2 (6.7%)

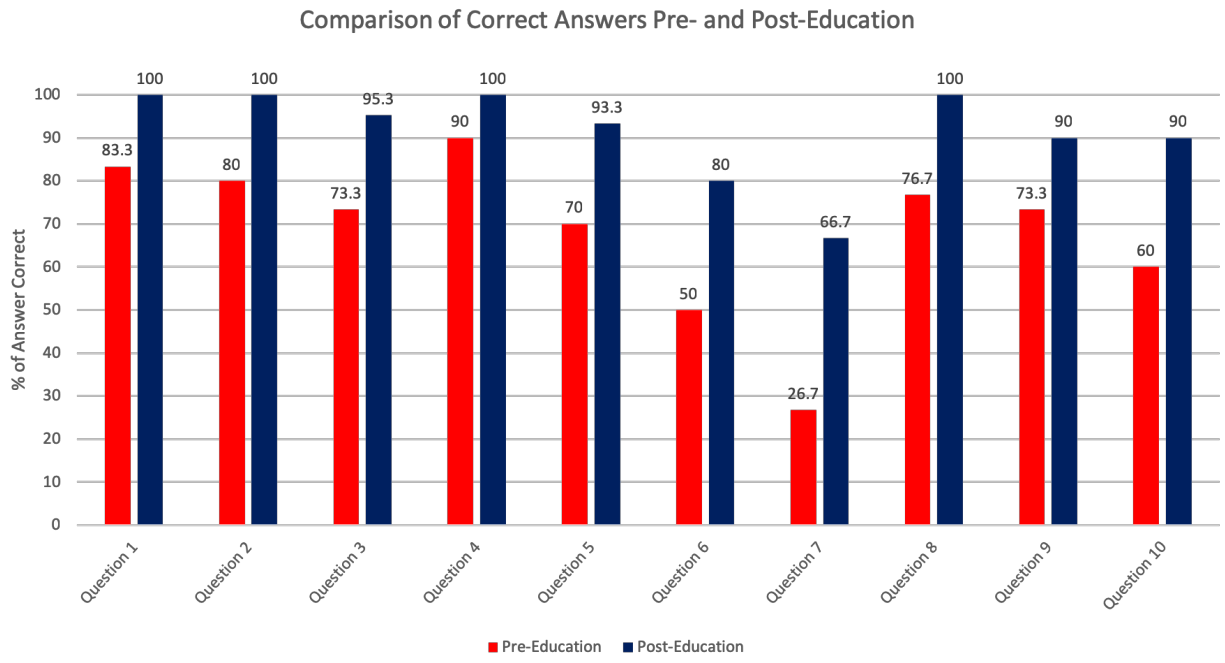
Table 2. *Comparison of Pre- and Post-Education Knowledge Levels*

	Pre-Education Mean (SD)	Post-Education Mean (SD)	*p*
Knowledge	6.87 (1.548)	9.10 (0.885)	<0.001

Table 3. *Comparison of Pre- and Post-Education Confidence Levels*

	Pre-Education Mean (SD)	Post-Education Mean (SD)	*p*
Confidence – Question 1	3.60 (0.814)	4.00 (0.587)	0.001
Confidence – Question 2	3.10 (0.147)	3.86 (0.108)	<0.001
Confidence – Question 3	3.13 (0.202)	4.00 (0.643)	<0.001
Average Confidence	3.277 (0.803)	3.945 (0.496)	<0.001

Figure 1. *Comparison of Correct Answers Pre- and Post-Education*



Appendix 1. *Cover Letter*

IRB Approval
9/5/2018
IRB # 45354
ID # 49737

Dear Prospective Research Participant:

Researchers at the University of Kentucky are inviting you to take part in a research study about continuous renal replacement therapy (CRRT) troubleshooting education and its effects on ICU nurses' knowledge and self-confidence levels. Before the education begins, you will be asked to complete a test and a questionnaire. These will be used to evaluate your baseline knowledge and self-confidence levels regarding CRRT troubleshooting. Immediately after the educational session has ended, you will be asked to complete the test and questionnaire again.

Although you may not get personal benefit from taking part in this research study, your responses may help us understand more about education methods and how nurses learn. Some volunteers experience satisfaction from knowing they have contributed to research that may possibly benefit others in the future. If you do not want to participate, there are other choices such as the standard online LEARN module about CRRT.

The education session, test, and questionnaire will take about 45 minutes to complete. In order to participate in this study, you must have ran CRRT at least once.

Although we have tried to minimize this, some questions may make you upset or feel uncomfortable and you may choose not to answer them. If some questions do upset you, we can tell you about some people who may be able to help you with these feelings.

Your response to the survey is anonymous; which means no names will appear/be used on research documents or be used in presentations/publications. The research team will not know that any information you provided came from you, nor that you even participated in the study. Your participation in this study is entirely voluntary and will have no effect on your status as an employee of Saint Joseph Hospital.

Your information collected for this study will NOT be used or shared for future research studies, even if we remove the identifiable information like your age, years of nursing experience, or ethnic origin.

We hope to receive completed questionnaires from about 40 people, so your answers are important to us. Of course, you have a choice about whether or not to complete the survey/questionnaire, but if you do participate, you are free to skip any questions or withdraw from the study at any time.

If you have questions about the study, please feel free to ask; my contact information is given below. If you have complaints, suggestions, or questions about your rights as a research volunteer, contact the staff in the University of Kentucky Office of Research Integrity at 859-257-9428 or toll-free at 1-866-400-9428.

Thank you in advance for your assistance with this important project.

Sincerely,

Lauren Nance
College of Nursing, University of Kentucky
PHONE: 270-217-5211
E-MAIL: lauren.nance@uky.edu

Appendix 2. *Demographic Survey*

Research Demographic Survey

Please indicate your gender.
☐ Male
☐ Female

Please indicate your ethnic origin.
☐ American Indian/Alaskan Native
☐ Asian
☐ Black/African American
☐ Hispanic/Latino
☐ Native Hawaiian/Pacific Islander
☐ White/Caucasian
☐ Other

Please indicate your age.
☐ 20-24
☐ 25-34
☐ 35-44
☐ 45-54
☐ 55-64
☐ 65 or above

Please indicate your degree level.
☐ Diploma
☐ Associate's
☐ Bachelor's

Please indicate your years of nursing experience.
☐ Less than a year
☐ 1-5 years
☐ 6-10 years
☐ 11-15 years
☐ 16-20 years
☐ 21-25 years
☐ 26-30 years
☐ 31 years or greater

Appendix 3. *Pre- and Post-Test*

CRRT Pre/Post-Test

1. In order to re-infuse blood after treatment has been terminated, which line must be disconnected from patient and connected to a 1-liter bag of sterile saline?
   A. *access line (red)*
   B. return line (blue)

2. Which is a cause of the alarm "Replacement weight (Incorrect weight change detected)?"
   A. incorrect bag of fluid has been hung
   B. not enough fluid in replacement bag
   C. *replacement bag is swinging on scale hook*
   D. replacement bag is empty

3. What is an appropriate action to the alarm "Filter Pressure Extremely Positive"?
   A. decrease patient fluid removal rate
   B. *decrease blood flow rate*
   C. decrease replacement fluid rate
   D. end treatment

4. For the alarm "Access pressure extremely negative," switching the access (red) and return (blue) lines is an appropriate action after other options have failed.
   A. *True*
   B. False

5. Where do you find how much anticoagulant to flush in lumens after treatment has ended?
   A. CRRT order set
   B. nursing communication in CERNER
   C. check with pharmacist
   D. *on the arterial and venous lumens*

6. What does a rise in TMP pressure indicate?
   A. *filter is clogging*
   B. filter is clotting
   C. patient fluid removal rate is set too high
   D. dialysis access is clotting

7. What does pressure drop indicate?
   A. filter is clogging
   B. *filter is clotting*
   C. patient is moving/coughing
   D. patient is hypotensive

8. How often should the deaeration chamber fluid level be checked?
   A. every four hours
   B. daily
   C. at the beginning of your shift
   D. *hourly*

9. The blood pump heads will stop turning if a yellow advisory alarm light appears.
    A. True
    B. *False*

10. What is the appropriate action to the alarm “Filter Clotted”?
    A. increase blood flow rate
    B. end treatment and re-infuse blood
    C. decrease patient fluid removal rate
    D. *end treatment and disconnect patient*

Appendix 4. *Pre- and Post-Questionnaire*

CRRT Pre/Post Questionnaire

1. I feel comfortable running CRRT? (Circle the best answer.)

1	2	3	4	5
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

2. I feel comfortable in my CRRT troubleshooting skills? (Circle the best answer.)

1	2	3	4	5
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

3. I feel comfortable re-infusing CRRT? (Circle the best answer.)

1	2	3	4	5
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

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